

Beneficial Management Practices to Reduce the Risk of Surface Water Contamination from Manured Agricultural Fields in South Coastal British Columbia

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[Editor's note: Figures for vanVliet and Derksen appear at the end of this paper.]

Abstract

The effectiveness of two Beneficial Management Practices (BMPs) in reducing solid and nutrient transport from agricultural fields were tested over a 5-year period using runoff plots (slope 3-5%). In years 1 and 2, the plots were planted with silage corn and the BMP treatment was intercropping with a relay crop of Italian ryegrass. In years 3 to 5, the plots were planted with orchard grass and the BMP treatment was mechanical soil aeration in the fall prior to manure application. In each case, liquid dairy manure was applied following common practices including amount and timing. Common practices are broadcasting manure by splash-plate on corn stubble in the fall (years 1 and 2) and on non-aerated orchard grass (years 3 to 5).

Surface runoff from each storm event was contained in a collection system. The number of runoff events per crop year varied from 13 to 31. Runoff samples were tested for total suspended solids (TSS), volatile solids (VS), total Kjeldahl nitrogen (TKN), and total phosphorus (TP).

Over years 1 and 2, TSS load from the intercrop treatment plots was reduced significantly to 2.3 t/ha from 9.0 t/ha for the common practice, an average reduction of 74%. VS load was also reduced significantly by 62% (from 1241 to 474 kg/ha), and nutrient loads were reduced between 42 and 56%. However, the relay crop was not considered effective in reducing contaminant concentrations and load from the early "first flush" events following fall manure application.

In years 3-5, treatment effects were significant for all variables measured. The average reduction in runoff from aeration was 78%; TSS load from aeration was reduced by 69%, VS by 80%, TKN load by 73% and TP load by 31%.

It was concluded that the two BMPs tested were very effective in reducing annual solids and nutrient loads from manured agricultural fields in South Coastal BC, but that there is still a high risk of contaminant loads during the initial "first flush" events immediately after fall manure application.

Introduction

The Fraser Valley, located in south coastal British Columbia, Canada, is a region of intensive agricultural production with high and ever increasing animal densities on a relatively small land-base, resulting in substantial nutrient surpluses (Schreier *et al.* 2000). Agricultural runoff water containing large amounts of contaminants (nutrients, sediment, and organic matter) places important habitats for fish and other aquatic organisms at risk.

While it is known that substantial quantities of runoff from agricultural land occur, estimates for only a few crops are available for south coastal BC conditions (van Vliet and Hall 1995; van Vliet *et al.* 1997). Many small streams in the Fraser Valley are important salmonid fish habitat and have been shown to be at risk. In one study, it was reported that nutrient concentrations and organic carbon were elevated at the agriculturally impacted downstream sites compared to the upper-reach, less impacted sites (Top *et al.* 1997). In addition, dissolved oxygen and percent saturation levels at the downstream sites were often below guidelines established for the protection of aquatic life.

In the Fraser Valley, runoff and contaminant loadings from manured corn and grassland is most likely to occur during the wet fall and winter seasons, when the majority of the annual rainfall occurs. The risk of contaminated runoff in the fall and winter from fall-applied manure is expected to be greater from fields under silage corn production than forage grass due to surface sealing of the exposed soil by raindrop impact and compaction from application of manure on wet

soils, resulting in a decreased infiltration rate. However, more recently, provincial guidelines strongly discourage late-season manure applications on harvested corn fields (now a decreasing practice) as well as the application of manure to grassland (including relay crops) from November to January.

The objective of this research was to estimate runoff and contaminant loadings, including solids and nutrients, from fall-manure application on test plots of slightly sloping silage cornland and forage grassland. Relay cropping of Italian ryegrass as a winter cover crop on cornland and soil aeration on grassland were evaluated as Beneficial Management Practices (BMP), summarized below:

Years 1 and 2 Compares Common Practice of Fall-Manured Bare Ground after Corn Harvest (corn stubble) with Fall-Manured Harvested Corn already Planted with a Relay Crop	Years 3 to 5 Compares Common Practice of Fall- Manured Grass with Aerated Fall-Manured Grass using an AerWay aerator
Common Practice = CP BMP = Relay Crop = RC	Without Aeration = NA BMP = With Aeration = AR

This paper presents the findings on solids and nutrients for the period between the last fall manure application and the beginning of next crop year, generally in mid-April.

Methods

Runoff plots (6 m wide and 21m long) were established at the Pacific Agriculture Research Centre (PARC) in Agassiz, which is located in the eastern part of the Fraser Valley of south coastal BC. The slope at the study site is irregular and varied from 3-5%. The soil at the site is developed on alluvial sediments, with a weakly developed soil profile, stone-free and moderately pervious, and classified as a Gleyed Humic Regosol (Entisol).

Each plot was configured to collect surface runoff by means of a 10 cm wide by 8 cm deep sheet-metal gutter across the down slope width of the plot, installed flush with the soil surface. The gutters drained into a 3700 L capacity system of galvanized steel culverts sealed at the bottom with concrete.

Precipitation was measured at the existing weather station at PARC. Total runoff from a rain event was contained in the collection system and runoff volume was determined. The contents of the collection tank were thoroughly mixed. During mixing and depending on water depth, either a grab or a depth-integrated sample was collected. Samples were handled and analyzed per standard procedures (Brakensiek *et al.* 1979; Eaton *et al.* 1995). The results for suspended and volatile solids, total Kjeldahl N and total phosphorus are presented in this paper.

The timing and amount of manure applied as N and other plot management information is shown in Figure 1 (years 1 to 2) and Figure 2 (years 3 to 5).

Results

Total monthly precipitation for the 5 years of study compared to the 30-year average is shown in Figure 3. Typically 70% of the total annual precipitation occurs over the fall and winter months. Year 5 had the least fall period precipitation while year 3 had the greatest.

The results showed that the presence of a relay crop as winter cover crop significantly reduced total and volatile solids losses from between 55% to 90% (Figure 4). Soil aeration reduced total and volatile solids losses from between 65% to 85% (Figure 5).

Losses of TKN and TP were also reduced due to the beneficial management practices (Tables 1 and 2). Regardless of the beneficial management practice (relay crop or soil aeration), the initial “first-flush” events (3) contributed appreciably to the overall cumulative total load of suspended solids (Figure 6) and other contaminants.

From preliminary analysis of lysimeter data, reflecting deep leaching below the root-zone (not shown), it appears that aeration increases concentrations of nitrate-N (33%) in the soil solution at 60 cm depth, but not at 120 cm depth.

Table 1. Losses of TKN and TP from runoff test plots with and without beneficial management practice.

kg/ha	(TKN)	(TKN)	(TP)	(TP)
Year and Treatment	CP	RL	CP	RL
Year 1	107.2	51.4	24.7	16.3
Year 2	89.8	35.5	17.7	8.3
	NA	AR	NA	AR
Year 3	2.68	0.55	1.48	0.13
Year 4	1.05	0.44	0.26	0.07
Year 5	0.49	0.20	0.06	0.02

Table 2. Reduction in runoff losses of TKN and TP due to beneficial management practice.

% reduction	(TKN)	(TP)
Year and Treatment	RL	RL
Year 1	52	34
Year 2	60	53
	AR	AR
Year 3	79	91
Year 4	58	73
Year 5	61	67

Conclusions

- Relay crops as winter cover crops in silage corn production and soil aeration on grassland appear to be very beneficial practices in reducing contaminant losses from fall-manured fields in south coastal BC.
- The initial “first-flush” events contribute an appreciable amount of solids and nutrients to the overall load and application buffers in high-risk field areas would be one means to reduce this risk.

A complete analysis of the results for years 1-2 are reported elsewhere: van Vliet, L.J.P., Zebarth, B.J. and Derksen, G. 2002. Can. J. Soil Sci. 82: 445-456. An analysis of the results for years 3 to 5 is currently in progress.

References

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Figures

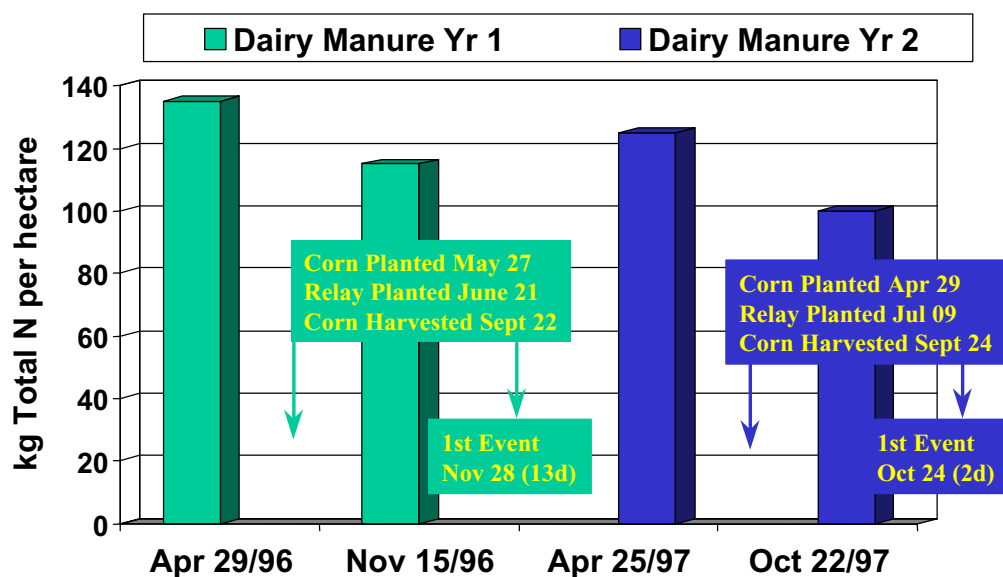


Figure 1. Silage Corn - Manure Application and Relay Plot Management.

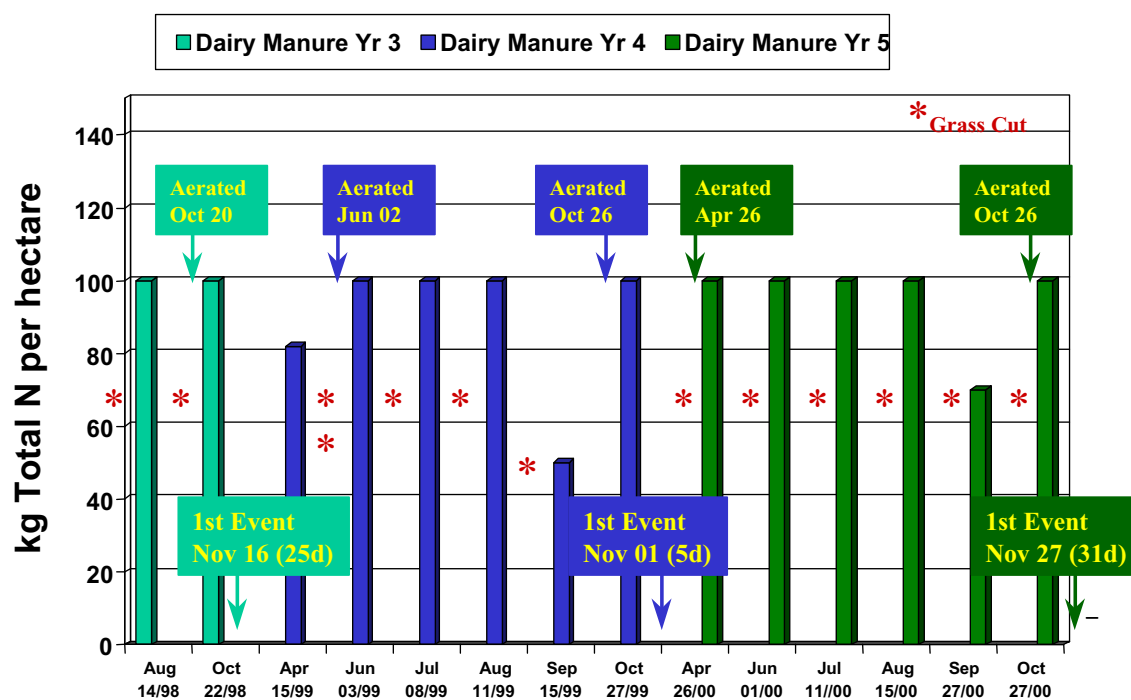


Figure 2. Orchard Grass - Manure Application and Soil Aeration Management.

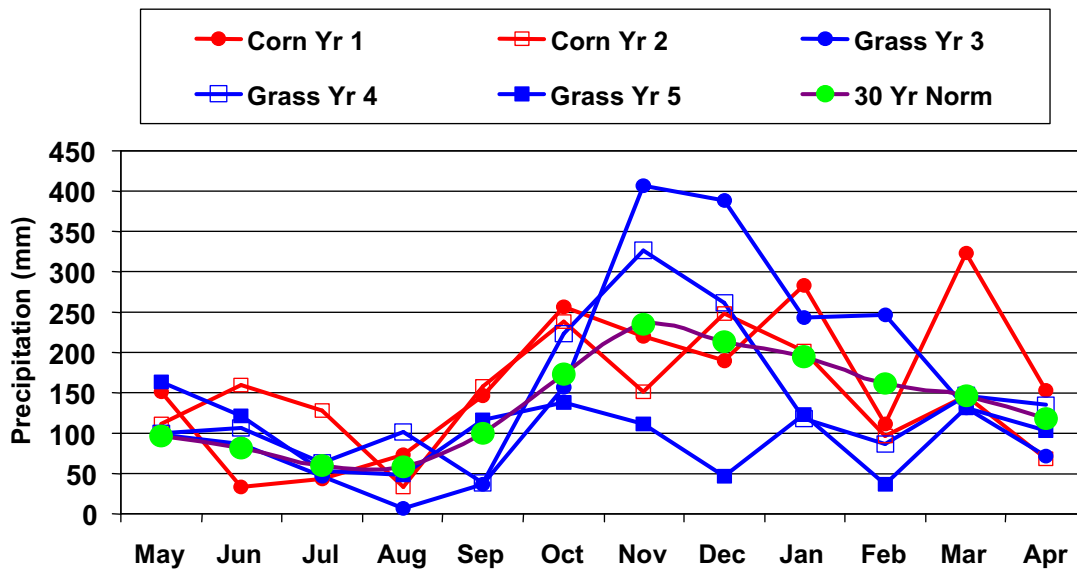


Figure 3. Total Monthly Precipitation Over Five Years of Corn and Grass Runoff Study and Thirty-Year Average at Agassiz, B.C..

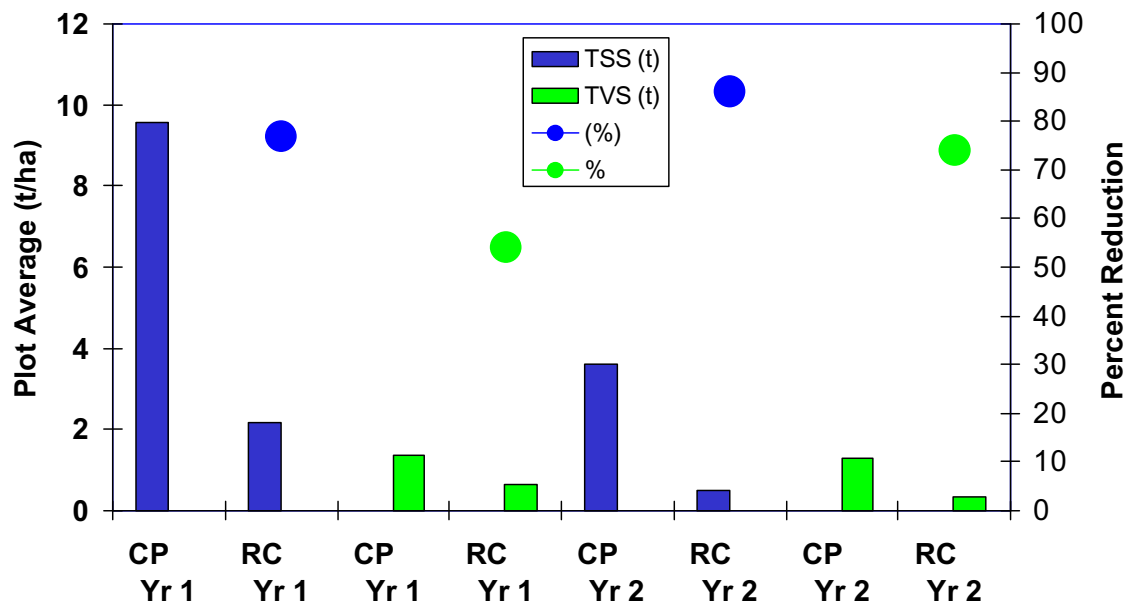


Figure 4. Cumulative Total Suspended and Total Volatile Solids Losses from Fall Manured Harvested Corn Test Plots. Without (CP) and With (RC) Relay Crop.

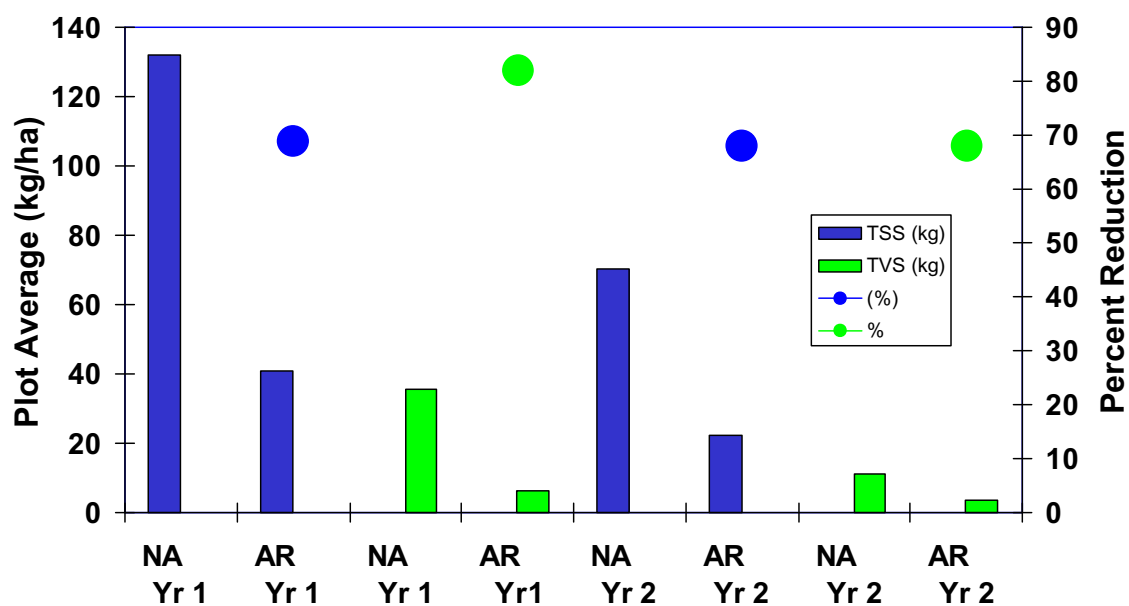


Figure 5. Cumulative Total Suspended and Total Volatile Solids Losses from Fall Manured Orchard Grass Test Plots. With (AR) and Without (NA) Soil Aeration.

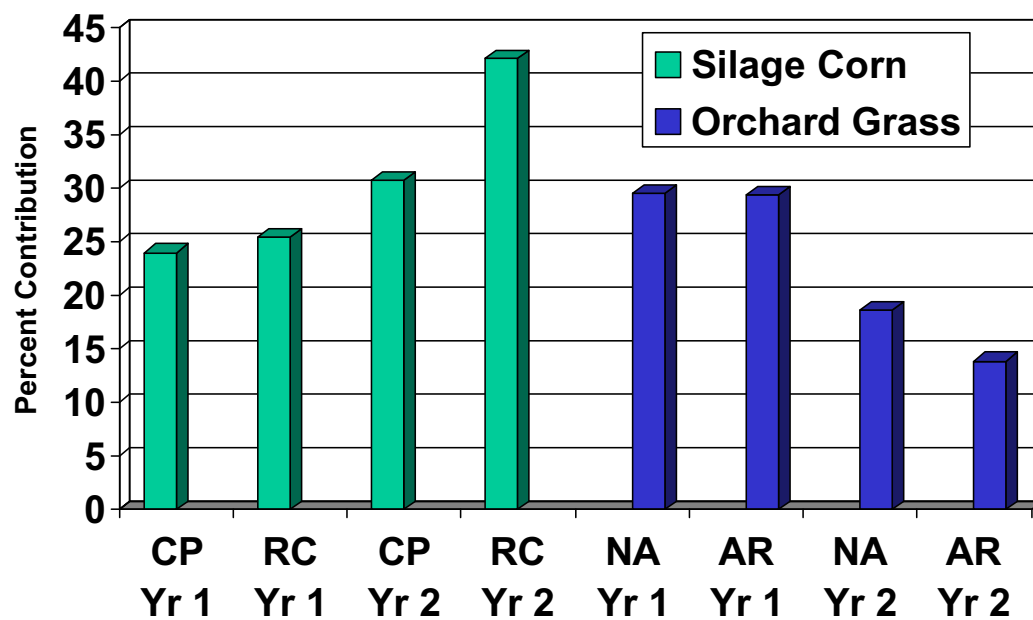


Figure 6. Contribution of First Flush Events to the Cumulative Suspended Solids Losses from Test Plots Under Different Management Practices.